CALIFORNIA
ENERGY
COMMISSION

AB 970 ENERGY EFFICIENCY STANDARDS for RESIDENTIAL AND NONRESIDENTIAL BUILDINGS

Express Terms: Proposed 15 Day Language Revisions for Permanent Adoption of January 3, 2001 Emergency Standards

including Nonresidential and Low-Rise Residential Alternative Calculation Method Approval Manuals

Proposed for Adoption April 4, 2001

COMMISSION PROPOSED STANDARDS

March 19, 2001
P400-01-009

Gray Davis, *Governor*

CALIFORNIA ENERGY COMMISSION

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Assembly Bill 970 Energy Efficiency Standards for Residential and Nonresidential Buildings

Express Terms: Proposed 15 Day Language Revisions for Permanent Adoption of January 3, 2001 Emergency Standards Including Nonresidential and Low-Rise Residential Alternative Calculation Method Approval Manuals

Energy Commission Publication No. P 400-01-009

These proposed 15 Day Language Revisions to the Emergency Energy Efficiency Standards, which were adopted by the California Energy Commission on January 3, 2001, are scheduled to be adopted by the California Energy Commission at its April 4, 2001 Business Meeting. The proposed standards are revisions to the Title 24 Building Energy Efficiency Standards (California Code of Regulations, Title 24, Part 6 and the Administrative Regulations, Title 24, Part 1).

March 19, 2001

PROPOSED "15 DAY LANGUAGE" REVISIONS

FOR THE PERMANENT ADOPTION OF THE

AB 970 EMERGENCY BUILDING ENERGY EFFICIENCY STANDARDS

March 19, 2001

Note: "15 Day Language" revisions are marked in double underline and ~~strikeout~~. "45 Day Language" revisions, which were adopted on January 3, 2001 as the emergency regulations and are the original "Express Terms" for the permanent adoption rulemaking, to the sections with proposed "15 Day Language" revisions are marked in single underline and ~~strikeout~~. Only sections with "15 Day Language" revisions are included in this document. Please see the emergency Standards (http://www.energy.ca.gov/reports/2001-01-04_400-01-001.PDF), Residential ACM Manual (http://www.energy.ca.gov/reports/2001-01-04_400-01-004.PDF), and Nonresidential ACM Manual (http://www.energy.ca.gov/reports/2001-01-04_400-01-003.PDF) for "45 day Language" revisions to sections for which "15 Day Language" revisions are not proposed.

PROPOSED REVISION TO TITLE 24, PART 1

1. Alternative Calculation Method Approval Manuals, Definitions, Update reference.

SECTION 10-102 – DEFINITIONS

In this article the following definitions apply:

ALTERNATIVE CALCULATION METHOD APPROVAL MANUAL or **ACM MANUAL** is the AB 970 Nonresidential Alternative Calculation Method (ACM) Approval Manual, ~~January~~April ~~4~~5, 2001 for the ~~1998~~2001 Energy Efficiency Standards for Nonresidential Buildings, ~~1998,~~ (P400-~~98~~01-011~~03~~~~11~~) for nonresidential buildings, hotels, and multi-family residential buildings with four or more stories and the AB 970 Low-Rise Residential Alternative Calculation Method (ACM) Approval Manual, ~~January~~April ~~4~~5, 2001 for the ~~1998~~2001 Energy Efficiency Standards for Residential Buildings, ~~1998,~~ (P400-~~98~~01-00124~~3~~) for all single family and low-rise multi-family residential buildings.

PROPOSED REVISIONS TO TITLE 24, PART 6

1. **Demand Control Ventilation, Nonresidential Mandatory Requirements, Clarification**

   Section 121(c)

   4. Demand Control Ventilation Devices shall:

      A. Allow the rate of outdoor air to be reduced to 0.15 cfm per square foot of conditioned floor area, if the demand control ventilation device indicates that the space conditions are acceptable; and

      B. Be approved by the commission; and

      C. If the device is a carbon dioxide sensor, limit the carbon dioxide level to no more than 800 ppm while the space is occupied; and

         Note: control to 800 ppm is not required when the ventilation rate is equal to or greater than that required by Section 121 (b) 2.

2. **Dampers, Nonresidential Mandatory Requirements, Elimination of requirements to avoid redundancy or conflict with existing Section 122(f)**

   Section 124

   ~~(f) All fan systems, regardless of volumetric capacity, that exhaust air from the building to the outside shall be provided with backdraft or automatic dampers to prevent air leakage.~~

   ~~(g) All gravity ventilating systems that serve conditioned space shall be provided with either automatic or readily accessible, manually operated dampers in all openings to the outside except combustion inlet and outlet air openings and elevator shaft vents.~~

3. **Radiant Barriers, Definition, Residential Prescriptive Requirements, List of Standards Referenced, Allowance of use of a second standard test procedure for emittance**

   Section 101

   RADIANT BARRIER is any reflective material that has an emittance of 0.05 or less, tested in accordance with ASTM C-1371-98 or ASTM E408-71(1996)e1, and that is certified to the California Department of Consumer Affairs.

Section 151(f)

2. **Radiant Barrier**. A radiant barrier required in Tables 1-Z1 through 1-Z16 is any reflective material that has an emittance of 0.05 or less, tested according to ASTM C-1371-98 or ASTM E408-71(1996)e1, and that is certified to the Department of Consumer Affairs. Installation criteria are contained in the Section 4.24 of the Residential ACM Manual.

Appendix 1-A

AMERICAN SOCIETY OF TESTING AND MATERIALS
ASTM E408-71(1996)e1 Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques

4. Refrigerant Charge and Airflow Measurement, Residential Package D Requirements, Establishment of an alternative to thermostatic expansion valve requirement

Section 151(f)

~~8~~7 **Space heating and space cooling.** When refrigerant charge and airflow measurement or thermostatic expansion valves are shown as required by Tables 1-Z1 through 1-Z16, ducted split system central air conditioners and ducted split system heat pumps shall either have refrigerant charge and airflow measurement confirmed through field verification and diagnostic testing in accordance with procedures set forth in the ACM Manual or shall be equipped with a thermostatic expansion valve (TXV) with an access door or removable panel to verify installation of the TXV. All TXVs shall be confirmed through field verification and diagnostic testing as specified in the ACM Manual. ~~The requirement for a TXV may be met by an equivalent alternative approved by the Commission.~~ All space-heating and space-cooling systems must comply with minimum appliance efficiency standards as specified in Sections 110 through 112.

TABLE 1-Z1—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 1

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R49	R38
Wood-frame walls	~~R19~~	~~R19~~	R29	R21
"Heavy mass" walls	~~(R8.5)~~	~~(R5.0)~~	NA	(R4.76)
"Light mass" walls	~~[R8.5]~~	~~[R6.0]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R19~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R8
Radiant barrier			NR	NR
GLAZING				
Maximum U-~~value~~factor[3]	~~0.65~~	~~0.65~~	0.40	0.65
Maximum total area	~~NR~~	~~16%~~	14%	16%
~~Maximum total nonsouth-facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south-facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~NR~~	~~NR~~	NR	NR
West-facing glazing	~~NR~~	~~NR~~	NR	NR
East-facing glazing	~~NR~~	~~NR~~	NR	NR
North-facing glazing	~~NR~~	~~NR~~	NR	NR
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			NR	NR
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~9~~8	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.55 U-factor and a 90% AFUE furnace or a 7.6 HSPF heat pump can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z2—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 2

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R49	R30
Wood-frame walls	~~R13~~	~~R19~~	R29	R13
"Heavy mass" walls	~~(R2.3)~~	~~(R2.2)~~	NA	(R2.44)
"Light mass" walls	~~[R4.5]~~	~~[R4.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R8
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.40	0.65
Maximum total area	~~NR~~	~~14%~~	16%	16%
~~Maximum total nonsouth-facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south-facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
East-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z3—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 3

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R38	R30
Wood-frame walls	~~R13~~	~~R19~~	R25	R13
"Heavy mass" walls	~~(R4.5)~~	~~(R3.5)~~	NA	(R2.44)
"Light mass" walls	~~[R5.0]~~	~~[R5.0]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R0
Radiant barrier			NR	NR
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.40	0.75
Maximum total area	~~NR~~	~~16%~~	14%	20%
~~Maximum total nonsouth-facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south-facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~NR~~	~~NR~~	NR	NR
West-facing glazing	~~NR~~	~~NR~~	NR	NR
East-facing glazing	~~NR~~	~~NR~~	NR	NR
North-facing glazing	~~NR~~	~~NR~~	NR	NR
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			NR	NR
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~9~~8	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.55 U-factor can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z4—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 4

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R38	R30
Wood-frame walls	~~R13~~	~~R19~~	R25	R13
"Heavy mass" walls	~~(R3.5)~~	~~(R3.5)~~	NA	(R2.44)
"Light mass" walls	~~[R5.0]~~	~~[R5.0]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R19~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R0
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.40	0.75
Maximum total area	~~NR~~	~~16%~~	14%	20%
~~Maximum total nonsouth-facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south-facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
East-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			NR	NR
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~9~~8	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z5—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 5

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R38	R30
Wood-frame walls	~~R19~~	~~R19~~	R25	R13
"Heavy mass" walls	~~(R2.4)~~	~~(R2.3)~~	NA	(R2.44)
"Light mass" walls	~~[R4.5]~~	~~[R4.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R0
Radiant barrier			NR	NR
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.40	0.75
Maximum total area	~~NR~~	~~14%~~	16%	16%
~~Maximum total nonsouth-facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south-facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~NR~~	~~NR~~	NR	NR
West-facing glazing	~~NR~~	~~NR~~	NR	NR
East-facing glazing	~~NR~~	~~NR~~	NR	NR
North-facing glazing	~~NR~~	~~NR~~	NR	NR
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			NR	NR
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~9~~8	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.55 U-factor can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z6—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 6

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R19~~	~~R30~~	R38	R30
Wood-frame walls	~~R13~~	~~R19~~	R21	R13
"Heavy mass" walls	~~(R1.5)~~	~~(R1.6)~~	NA	(R2.44)
"Light mass" walls	~~[R4.0]~~	~~[R4.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R21	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R0
Radiant barrier			NR	NR
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.50	0.75
Maximum total area	~~NR~~	~~16%~~	14%	20%
~~Maximum total nonsouth-facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south-facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~NR~~	~~NR~~	NR	NR
West-facing glazing	~~NR~~	~~NR~~	NR	NR
East-facing glazing	~~NR~~	~~NR~~	NR	NR
North-facing glazing	~~NR~~	~~NR~~	NR	NR
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			NR	NR
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~9~~8	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.55 U-factor can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z7—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 7

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R19~~	~~R30~~	R38	R30
Wood-frame walls	~~R13~~	~~R13~~	R21	R13
"Heavy mass" walls	~~(R1.7)~~	~~(R1.4)~~	NA	(R2.44)
"Light mass" walls	~~[R4.0]~~	~~[R3.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~NR~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R13~~	R21	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R0
Radiant barrier			NR	NR
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.50	0.75
Maximum total area	~~NR~~	~~14%~~	14%	20%
~~Maximum total nonsouth-facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south-facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
East-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			NR	NR
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~9~~8	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z8—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 8

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R38	R30
Wood-frame walls	~~R13~~	~~R19~~	R21	R13
"Heavy mass" walls	~~(R1.6)~~	~~(R1.6)~~	NA	(R2.44)
"Light mass" walls	~~[R4.0]~~	~~[R4.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~NR~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R21	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R0
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.50	0.75
Maximum total area	~~NR~~	~~14%~~	14%	20%
~~Maximum total nonsouth-facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south-facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~0.40~~	~~0.40~~	0.40	~~NR~~0.40
West-facing glazing	~~0.40~~	~~0.40~~	0.40	0.40
East-facing glazing	~~NR~~	~~NR~~	0.40	0.40
North-facing glazing	~~NR~~	~~NR~~	0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~9~~8	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z9—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 9

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R38	R30
Wood-frame walls	~~R13~~	~~R19~~	R21	R13
"Heavy mass" walls	~~(R1.4)~~	~~(R1.5)~~	NA	(R2.44)
"Light mass" walls	~~[R4.0]~~	~~[R4.0]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R21	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R0
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.50	0.75
Maximum total area	~~NR~~	~~14%~~	14%	20%
~~Maximum total nonsouth facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~0.40~~	~~0.40~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~0.40~~	~~0.40~~	0.40	0.40
East-facing glazing	~~NR~~	~~NR~~	0.40	0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air to air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and an 11.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required NA = Not Applicable
REQ = Required MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z10—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 10

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R49	R30
Wood-frame walls	~~R13~~	~~R19~~	R25	R13
"Heavy mass" walls	~~(R1.9)~~	~~(R2.0)~~	NA	(R2.44)
"Light mass" walls	~~[R4.5]~~	~~[R4.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R0
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~1.10~~	~~0.65~~	0.40	0.~~7~~65
Maximum total area	~~NR~~	~~16%~~	16%	20%
~~Maximum total nonsouth facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~0.40~~	~~0.40~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~0.40~~	~~0.40~~	0.40	0.40
East-facing glazing	~~NR~~	~~NR~~	0.40	0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and an 11.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required
REQ = Required
NA = Not Applicable
MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z11—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 11

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R49	R38
Wood-frame walls	~~R13~~	~~R19~~	R29	R19
"Heavy mass" walls	~~(R5.0)~~	~~(R5.5)~~	NA	(R4.76)
"Light mass" walls	~~[R6.0]~~	~~[R6.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R8
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~0.65~~	~~0.65~~	0.40	0.65
Maximum total area	~~NR~~	~~14%~~	16%	16%
~~Maximum total nonsouth facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~0.40~~	~~0.40~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~0.40~~	~~0.40~~	0.40	0.40
East-facing glazing	~~NR~~	~~NR~~	0.40	0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and an 11.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required
REQ = Required
NA = Not Applicable
MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z12—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 12

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R49	R38
Wood-frame walls	~~R13~~	~~R19~~	R29	R19
"Heavy mass" walls	~~(R3.5)~~	~~(R3.5)~~	NA	(R4.76)
"Light mass" walls	~~[R5.0]~~	~~[R5.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~NR~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R4
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~0.65~~	~~0.65~~	0.40	0.65
Maximum total area	~~NR~~	~~14%~~	16%	16%
~~Maximum total nonsouth facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~0.40~~	~~0.40~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~0.40~~	~~0.40~~	0.40	0.40
East-facing glazing	~~NR~~	~~NR~~	0.40	0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and an 11.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required
REQ = Required
NA = Not Applicable
MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z13—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 13

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R30~~	R49	R38
Wood-frame walls	~~R13~~	~~R19~~	R29	R19
"Heavy mass" walls	~~(R4.0)~~	~~(R4.0)~~	NA	(R4.76)
"Light mass" walls	~~[R5.5]~~	~~[R6.0]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~NR~~	~~R7~~	R7	NR
Raised floors	~~R13~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R8
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~0.65~~	~~0.65~~	0.40	0.65
Maximum total area	~~NR~~	~~14%~~	16%	16%
~~Maximum total nonsouth facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~0.40~~	~~0.40~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~0.40~~	~~0.40~~	0.40	0.40
East-facing glazing	~~NR~~	~~NR~~	0.40	0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and a 12.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required
REQ = Required
NA = Not Applicable
MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z14—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 14

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R38~~	~~R38~~	R49	R38
Wood-frame walls	~~R19~~	~~R19~~	R29	R21
"Heavy mass" walls	~~(R7.0)~~	~~(R5.5)~~	NA	(R4.76)
"Light mass" walls	~~[R8.0]~~	~~[R6.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R19~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R8
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~0.65~~	~~0.65~~	0.40	0.65
Maximum total area	~~NR~~	~~16%~~	14%	16%
~~Maximum total nonsouth facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~0.15~~	~~0.15~~	~~NR~~0.40	~~NR~~0.40
West-facing glazing	~~0.15~~	~~0.15~~	0.40	0.40
East-facing glazing	~~NR~~	~~NR~~	0.40	0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.30 Solar Heat Gain Coefficient, and a 12.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required
REQ = Required
NA = Not Applicable
MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z15—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 15

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R30~~	~~R38~~	R49	R38
Wood-frame walls	~~R19~~	~~R19~~	R29	R21
"Heavy mass" walls	~~(R5.5)~~	~~(R4.5)~~	NA	(R4.76)
"Light mass" walls	~~[R7.0]~~	~~[R6.0]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R0
Slab floor perimeter	~~R7~~	~~R7~~	R7	NR
Raised floors	~~R19~~	~~R19~~	R21	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R4
Radiant barrier			REQ	REQ
GLAZING				
Maximum U-~~value~~factor[3]	~~0.65~~	~~0.65~~	0.40	0.65
Maximum total area	~~NR~~	~~16%~~	16%	16%
~~Maximum total nonsouth facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~0.15~~	~~0.15~~	0.40	0.40
West-facing glazing	~~0.15~~	~~0.15~~	0.40	0.40
East-facing glazing	~~NR~~	~~NR~~	0.40	0.40
North-facing glazing	~~NR~~	~~NR~~	~~NR~~0.40	~~NR~~0.40
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			REQ	REQ*
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.30 Solar Heat Gain Coefficient, and a 13.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:
NR = Not Required
REQ = Required
NA = Not Applicable
MIN = Minimum

See notes following Table 1-Z16

TABLE 1-Z16—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 16

COMPONENT	PACKAGE[1]			
	~~A~~	~~B~~	C[1]	D
BUILDING ENVELOPE				
Insulation minimums[2]				
Ceiling	~~R38~~	~~R38~~	R49	R38
Wood-frame walls	~~R19~~	~~R19~~	R29	R21
"Heavy mass" walls	~~(R9.5)~~	~~(R7.0)~~	NA	(R4.76)
"Light mass" walls	~~[R9.5]~~	~~[R7.5]~~	NA	NA
Below-grade walls	~~NA~~	~~NA~~	NA	R13
Slab floor perimeter	~~R7~~	~~R7~~	R7	R7
Raised floors	~~R19~~	~~R19~~	R30	R19[2]
Concrete raised floors	~~NA~~	~~NA~~	NA	R8
Radiant barrier			NR	NR
GLAZING				
Maximum U-~~value~~factor[3]	~~0.65~~	~~0.65~~	0.40	0.60
Maximum total area	~~NR~~	~~16%~~	14%	16%
~~Maximum total nonsouth facing area~~	~~9.6%~~	~~NR~~	~~NR~~	~~NR~~
~~Minimum south facing area~~	~~6.4%~~	~~NR~~	~~NR~~	~~NR~~
SOLAR HEAT GAIN COEFFICIENT[4]				
South-facing glazing	~~NR~~	~~NR~~	NR	NR
West-facing glazing	~~NR~~	~~NR~~	NR	NR
East-facing glazing	~~NR~~	~~NR~~	NR	NR
North-facing glazing	~~NR~~	~~NR~~	NR	NR
THERMAL MASS[5]	~~REQ~~	~~NR~~	REQ	NR
~~INFILTRATION CONTROL~~				
~~Continuous barrier~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
~~Air-to-air heat exchanger~~	~~NR~~	~~REQ~~	~~NR~~	~~NR~~
SPACE-HEATING SYSTEM[6]				
Electric-resistant allowed	~~No~~	~~No~~	Yes[7]	No
If gas, AFUE =	~~78%~~	~~78%~~	78%	MIN
If heat pump, split system HSPF[8] =	~~6.8~~	~~6.8~~	6.8	MIN
Single package system HSPF =	~~6.6~~	~~6.6~~	6.6	MIN
SPACE-COOLING SYSTEM				
If split system A/C, SEER =	~~10.0~~	~~10.0~~	10.0	MIN
Refrigerant charge and airflow measurement or Thermostatic expansion valve			NR	NR
If single package A/C, SEER =	~~9.7~~	~~9.7~~	9.7	MIN
SPACE CONDITIONING DUCTS				
Duct sealing			REQ	REQ*
DOMESTIC WATER-HEATING TYPE				
System must meet budget, see Section 151 (b) 1 and (f) ~~98~~	~~Any~~	~~Any~~	Any[9]	Any

*As an alternative under Package D, glazing with a maximum 0.55 U-factor and a 90% AFUE furnace or a 7.6 HSPF heat pump can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:
NR = Not Required
REQ = Required
NA = Not Applicable
MIN = Minimum

See notes following Table 1-Z16

3. Thermostatic Expansion Valves or Refrigerant Charge and Airflow Measurement, Alterations in Existing Residential Buildings, Establishment of prescriptive requirement

Section 152(b)1

B. New space-conditioning systems or components shall:

i. Meet the requirements of Sections 150 (h) and (i) and Section 151(f)7; and

PROPOSED REVISIONS TO THE RESIDENTIAL ACM MANUAL

1. Radiant Barriers, Allowance for second test procedure, Clarification of ventilation requirements

4.24 Radiant Barriers

Standard Design: The *Standard Design* ~~does not have or use~~ has a radiant barrier~~s~~ in accordance with Package D requirements.

Proposed Design: ~~Energy credit for radiant barriers may be used with approved 1998 alternative calculation methods (ACMs). Approved ACMs must be able to model radiant barriers. The reference method models r~~Radiant barriers are modeled by calculating ceiling U-value modifiers that are functions of the ceiling insulation and the season and by using different seasonal attic temperatures for attics with radiant barriers which result in better HVAC distribution efficiencies for ducts in the attic below a radiant barrier.

Radiant barriers must meet specific eligibility and installation criteria to be modeled by any ACM and receive energy credit for compliance with the energy efficiency standards for low-rise residential buildings.

- The ~~emissivity~~ emittance of the radiant barrier must be less than or equal to 0.05 as tested in accordance with ASTM ~~Test Method~~ C-1371-9~~7~~8 or ASTM E408-71(1996)e1.
- Installation must be in conformance with ASTM C-1158-97 (Standard Practice For Use and Installation Of Radiant Barrier Systems (RBS) In Building Construction.), ASTM C-727-90(1996)e1 (Standard Practice For Installation and Use Of Reflective Insulation In Building Constructions.), ASTM C1313-9~~7~~5 (Standard Specification for Sheet Radiant Barriers for Building Construction Applications), and ASTM C-1224-9~~9~~3 (Standard Specification for Reflective Insulation for Building Applications) and the radiant barrier must be securely installed in a permanent manner with the shiny side facing down toward the attic floor. Moreover, radiant barriers must be installed to the roof truss/rafters (top chords) in ***any*** of the following methods, with the material:
    1. Draped over the truss/rafter (the top chords) before the upper roof decking is installed.
    2. Spanning between the truss/rafters (top chords) and secured (stapled) to each side.
    3. Secured (stapled) to the bottom surface of the truss/rafter (top chord). A minimum air space must be maintained between the top surface of the radiant barrier and roof decking of not less than 1.5 inches at the center of the truss/rafter span.
    4. Attached [laminated] directly to the underside of the roof decking. The radiant barrier must be laminated and perforated by the manufacturer to allow moisture/vapor transfer through the roof deck.

  In addition, the radiant barrier must be installed to cover all gable end walls and other vertical surfaces in the attic.

- The attic must be ventilated to:
    1. conform to manufacturer's instructions.
    2. provide a minimum free ventilation area of not less than one square foot of vent area for each 150 square feet of attic floor area.
    3. provide no less than 30 percent upper vents.
    4. ~~have a minimum gap of 3.5 inches between the bottom of the radiant barrier and the top of the ceiling insulation to allow ventilation air to flow between the roof decking and the top surface of the radiant barrier (except for method 4 above).~~
    5. ~~have a minimum of six (6) inches (measured horizontally) left at the roof peak to allow hot air to escape from the air space between the roof decking and the top surface of the radiant barrier (except for method 4 above).~~

(Ridge vents or gable end vents are recommended to achieve the best performance. The material should be cut to allow for full air flow to the venting.)

- The radiant barrier must be installed to:
    1. have a minimum gap of 3.5 inches between the bottom of the radiant barrier and the top of the ceiling insulation to allow ventilation air to flow between the roof decking and the top surface of the radiant barrier (except for method 4 above).
    2. have a minimum of six (6) inches (measured horizontally) left at the roof peak to allow hot air to escape from the air space between the roof decking and the top surface of the radiant barrier (except for method 4 above).
- When installed in enclosed rafter spaces where ceilings are applied directly to the underside of roof rafters, a minimum air space of 1 inch must be provided between the radiant barrier and the top of the ceiling insulation, and ventilation must be provided for every rafter space. Vents must be provided at both the upper and lower ends of the enclosed rafter space.
- The product must meet all requirements for California certified insulation materials [radiant barriers] of the Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation as indicated in the *Consumer Guide and Directory of Certified Insulation Products.*

The use of a radiant barrier and the criteria specified above for covering all gable end walls and other vertical surfaces in the attic, and for providing attic ventilation shall be listed in the *Special Features and Modeling Assumptions* listings of the CF-1R and C-2R and described in detail in the ACM Compliance Supplement.

For the heating season, Equation 4.46 is the expression for the U-value modifier; for the cooling season, Equation 4.47. To determine the U-value for a ceiling with a radiant barrier, multiply the U-value of the ceiling assembly without the radiant barrier times the U-value modifier. The U-value modifiers are calculated from equations 4.46 and 4.47.

For installed insulation greater than R-8:

$$UvalMod_{heating} = (-11.404 \times U^2) + (0.21737 \times U) + 0.92661 \qquad \text{Equation 4.1}$$

$$UvalMod_{cooling} = (-58.511 \times U^2) + (3.22249 \times U) + 0.64768 \qquad \text{Equation 4.2}$$

Otherwise these modifiers are 1.000.

2. Refrigerant Charge and Airflow Measurement, Establishment of an alternative to Thermostatic Expansion Valves

2.1 Certificate of Compliance (CF-1R)

…

HVAC Systems. This listing provides data on the heating and cooling systems in the building. These data are identical to those in the Computer Method Summary (Report C-2R) under "HVAC Systems" described on Page 2-34.

HVAC SYSTEMS

System Name	System Type	Refrigerant Charge and Airflow ~~TXV~~	Minimum Equipment Efficiency	Distribution Type and Location	Duct R-value
Zone=Living					
LowerHeat	GasFurnace	N/A	0.78 AFUE	DuctsCrawl	4.2
LowerAC	AirCond-Split	Yes	10.0 SEER	DuctsCrawl	4.2
Zone=Sleep					
UpperHeat	Electric	N/A	1.00 COP	Baseboard	
UpperAC	AirCond-Split	No	10.0 SEER	DuctsAttic	4.2

…

- ~~*TXV*~~*Refrigerant Charge and Airflow*: Whether the refrigerant charge and airflow is verified or a thermostatic expansion valve is included for ducted central systems. The choices are 'yes' or 'no' where "yes" means that either refrigerant charge and airflow are verified or a TXV is installed. Only split system equipment (*SplitAirCond and SplitHeatPump)* can be modeled with refrigerant charge and airflow verification. Six equipment types can be modeled with a TXV. They are: *SplitAirCond*, *PkgAirCond*, *LrgPkgAirCond*, *SplitHeatPump*, *PkgHeatPump*, *LrgPkgHeatPump*. See Table 2-3 for a description of equipment.

…

2.1.1 Computer Method Summary (C-2R)

…

HVAC Systems

…

HVAC SYSTEMS

Equipment Type	Minimum Equipment Efficiency (or Water Heating System Name)	Refrigerant Charge and Airflow ~~Thermostatic Expansion Valve~~	Distribution Type and Location	Duct R-value
Zone=Living				
Furnace	0.78 AFUE	N/A	DuctsCrawl	4.2
AirCond-Split	10.0 SEER	Yes	DuctsCrawl	4.2
Zone=Sleep				
CombHydro	Upper Floors	N/A	Baseboard	na.
AirCond-Split	10.0 SEER	No	DuctsAttic	4.2

…

- *Refrigerant Charge and Airflow* ~~*Thermostatic Expansion Valve*~~. The choices ~~for TXV~~ are 'yes' or 'no' where "yes" means that either refrigerant charge and airflow are verified or a TXV is installed. See Section 2.1 for system types for which ~~TXV~~this credit can be claimed.

…

3.8.2 Cooling Equipment

-

…

The ~~thermostatic expansion valve (TXV)~~ refrigerant charge and airflow factor (F_{TXV}), which adjusts the system performance ~~to account for the presence of a TXV~~, shall be 1.0 for systems without refrigerant charge and airflow measurement or a TXV. For systems with refrigerant charge and airflow measurement or a TXV, the ~~thermostatic expansion valve~~ refrigerant charge and airflow factor shall be 1.07 for duct systems designed according to ACCA Manual D and 1.11 for all other duct systems.

3.8.3 ~~Thermostatic Expansion Valves~~ Refrigerant Charge and Airflow

Proposed Design: The ACM must allow the user to enter a central ducted cooling system with a refrigerant charge and airflow option ~~thermostatic expansion valve (TXV)~~. The~~e~~is option requires either measuring charge and airflow using procedures set forth in Appendix K (for split system equipment only) or requires the presence of a thermostatic expansion valve (TXV). These features require~~s~~ verification by the HERS rater and must be reported in the *Special Features and Modeling Assumptions and HERS Required Verification* listings on the CF-1R and C-2R.

Standard Design: If a split system ducted central air conditioner or heat pump (*SplitAirCond* or *SplitHeatPump*) is used for the *Proposed Design* then the cooling system used in the *Standard Design* building shall have either refrigerant charge and air flow measurement or be equipped with a thermostatic expansion valve if required by Package D.

Adjustments to the source seasonal energy efficiency ratio due to refrigerant charge and airflow or thermostatic expansion valves are described in section 3.8.2.

7. Home Energy Rating Systems (HERS) Required Verification and Diagnostic Testing

…

7.2 HERS Required Verification and Diagnostic Testing

HERS diagnostic testing and field verification is required for ~~compliance credit for~~:

- Duct sealing
- ACCA Manual D and installation
- Refrigerant charge and airflow measurement, and
- ~~And b~~Building envelope sealing beyond improvements covered by default assumptions.

7.3 Install~~ation~~~~er~~ Certification

When compliance ~~credit has been claimed for~~ includes duct sealing, ACCA Manual D design and installation, refrigerant charge and airflow measurement ~~and~~or envelope sealing, builder employees or subcontractors shall:

- complete diagnostic testing, and
- certify on the CF-6R the diagnostic test results and that the work meets the requirements for compliance credit.

For refrigerant charge and airflow measurement when the outside temperature is below 55°F, the installer shall follow the alternate charge and airflow measurement procedure described in Appendix K, Section 3. Builder employees or subcontractors using these procedures shall certify on the CF-6R that they used these procedures, the diagnostic results, that the work meets the requirements for compliance credit, and that they will return to correct refrigerant charge and airflow if the HERS rater determines at a later time when the outside temperature is above 55°F that correction is necessary.

…

7.4 HERS Verification Procedures

… Field verification and diagnostic testing for compliance credit for duct sealing shall use the diagnostic duct leakage from fan pressurization of ducts in Section 4.3.8.2.1 of Appendix F.

Field verification and diagnostic testing for compliance credit for refrigerant charge and airflow measurement shall use the standard charge and airflow measurement procedure specified in Appendix K. Field verification and diagnostic testing shall not use the alternate charge and airflow measurement procedure. Field verification and

diagnostic testing shall be scheduled and completed when the outside temperature is above 55°F.

…

7.5.3 Building Department

…

For ~~house~~dwelling units that have used a compliance alternative that requires field verification and diagnostic testing, the building department shall not approve a ~~house~~dwelling unit for occupancy until the building department has received from the builder a *Certificate of Field Verification and Diagnostic Testing* that has been signed and dated by the HERS rater.

If necessary to avoid delay of approval of dwelling units completed when outside temperatures are below 55°F, building departments may approve compliance credit for refrigerant charge and airflow measurement when installers have used the alternate charging and airflow measurement procedure described in Appendix K, Section 3. This approval will be on the condition that installers provide a signed agreement (CF-6R) to the builder with a copy to the building department to return to correct refrigerant charge and airflow if the HERS rater determines at a later time when the outside temperature is above 55°F that correction is necessary.

Appendix K Procedures for Determining Required Refrigerant Charge and Adequate Airflow for Split System Space Cooling Systems without Thermostatic Expansion Valves

1. Overview

Failure to maintain proper refrigerant charge or proper airflow across the coil reduces the seasonal energy efficiency for an air conditioner (whether a cooling only air conditioner or a heat pump). In addition, excessive refrigerant charge can cause premature compressor failure, while insufficient refrigerant charge allows compressors to overheat. Very low airflow can result in icing of the coil and compressor failure.

To help avoid these problems and to provide a compliance credit for correctly installed systems, this appendix describes procedures for determining if a residential split system space cooling system has the required refrigerant charge and adequate airflow across the evaporator coil. The applicability of these procedures have the following limitations:

- The procedures detailed in this appendix only apply to ducted split system central air conditioners and ducted split system central heat pumps that do not have thermostatic expansion valves (TXVs).
- As an alternative to the procedures detailed in this appendix, systems may substitute a TXV installed and confirmed through field verification and diagnostic testing.
- The procedures detailed in this appendix do not apply to single packaged systems.

Note that the procedures detailed in this appendix are intended to be used after the HVAC installer has installed and charged the system in accordance with the manufacturer's specifications.

The installer shall install and charge the air conditioner and heat pump equipment in accordance with the manufacturer's instructions and specifications for the specific model equipment installed. The installer shall certify to the builder, building official and HERS rater that they have followed these instruction and specifications prior to proceeding with the procedures in this appendix.

For dwelling units with multiple systems, this procedure must be applied to each system separately.

This appendix defines two procedures, the Standard Charge and Airflow Measurement procedure in Section 2 and the Alternate Charge and Airflow Measurement procedure in Section 3. The Standard procedure shall be used when the outdoor air temperature is 55°F or above and shall always be used for HERS rater verification. HVAC installers who must complete system installation when the outdoor temperature is below 55°F shall use the Alternate procedure.

The following sections document the instrumentation needed, the required instrumentation calibration, the measurement procedure, and the calculations required for each procedure.

2. Standard Charge and Airflow Measurement Procedure

This section specifies the Standard charge and airflow measurement procedure. Under this procedure, required refrigerant charge is calculated using the *Superheat Charging Method* and adequate airflow across the evaporator coil is calculated using the *Temperature Split Method.*

The Standard procedure detailed in this section shall be completed when the outdoor temperature is 55°F or higher after the HVAC installer has installed and charged the system in accordance with the manufacturer's specifications. All HERS rater verifications are required to use this Standard procedure.

2.1 Minimum Qualifications for this Procedure

Persons carrying out this procedure need to be qualified to perform the following:

- Obtain accurate pressure/temperature readings from refrigeration manifold gauges.
- Obtain accurate temperature readings from thermometer and thermocouple set up.
- Check calibration of refrigerant gauges using a known reference pressure and thermometer/thermocouple set up using a known reference temperature.
- Determine best location for temperature measurements in ducting system and on refrigerant lineset.
- Calculate the measured superheat and temperature split.
- Determine the correct level of superheat and temperature split required, based on the conditions present at the time of the test.
- Determine if measured values are reasonable.

2.2 Instrumentation Specifications

Instrumentation for the procedures described in this section shall conform to the following specifications.

2.2.1 Digital Thermometer

Digital thermometer must have thermocouple compatibility (type K and J) and Celsius or Fahrenheit readout with:

- Accuracy: ±(0.1% of reading + 1.3º F)
- Resolution: 0.2º F

2.2.2 Thermocouples

Measurements require five (5) heavy duty beaded low-mass wire thermocouples and one (1) cotton wick for measuring wet-bulb temperatures.

2.2.3 Refrigerant Manifold Gauge Set

A standard multiport refrigerant manifold gauge with an accuracy of plus or minus 3% shall be used.

2.3 Calibration

The accuracy of instrumentation shall be maintained using the following procedures. A sticker with the calibration check date shall be affixed to each instrument calibrated.

2.3.1 Thermometer/Thermocouple Field Calibration Procedure

Thermometers/thermocouples shall be calibrated monthly to ensure that they are reading accurate temperatures. The following procedure shall be used to check thermometer/thermocouple calibration.

Step 1. Fill an insulated cup (foam) with crushed ice. The ice shall completely fill the cup. Add water to fill the cup.

Step 2. Insert two thermocouples into the center of the ice bath and attach them to the digital thermometer.

Step 3. Let the temperatures stabilize. The temperatures shall be 32°F (+/- 1°F). If the temperature is off by more than 1°F make corrections according to the manufacturer's instructions. Any thermocouples that are off by more than 3°F shall be replaced.

Step 4. Switch the thermocouples and ensure that the temperatures read on T1 and T2 are still within +/- 1°F of 32°F.

Step 5. Affix sticker with calibration check date onto thermocouple.

Step 6. Repeat the process for all thermocouples.

2.3.2 Refrigerant Gauge Field Check Procedure

Refrigerant gauges shall be checked monthly to ensure that the gauges are reading the correct pressures and corresponding temperatures. The following procedure shall be used to check gauge calibration.

Step 1. Place a refrigerant cylinder in a stable environment and let it sit for 4 hours minimum to stabilize to the ambient conditions.

Step 2. Attach a thermocouple to the refrigerant cylinder using duct tape so that there is good contact between the cylinder and the thermocouple.

Step 3. Insulate the thermocouple connection to the cylinder (closed cell pipe insulation can be taped over the end of the thermocouple to provide the insulation).

Step 4. Zero the low side compound gauge with all ports open to atmospheric pressure (no hoses attached).

Step 5. Re-install the hose and attach the low side gauge to the refrigerant cylinder.

Step 6. Read the temperature of the thermocouple.

Step 7. Using a pressure/temperature chart for the refrigerant, look up the pressure that corresponds to the temperature measured.

Step 8. If gauge does not read the correct pressure corresponding to the temperature, the gauge is out of calibration and needs to be replaced or returned to the manufacturer for calibration.

Step 9. Repeat the process in steps 4 through 8 for the high side gauge.

Step 10. Affix sticker with calibration check date onto refrigerant gauge.

2.4 Charge and Airflow Measurements

The following procedure shall be used to obtain measurements necessary to adjust required refrigerant charge and adequate airflow as described in the following sections.

Step 1. Establish a return air dry bulb temperature sufficiently high that the return air dry bulb temperature will be not less than 70^{o}F prior to the measurements at the end of the 15 minute period in step 2.

Step 2. Turn the cooling system on and let it run for 15 minutes to stabilize temperatures and pressures before taking any measurements. While the system is stabilizing, proceed with setting up the temperature measurements.

Step 3. Connect the refrigerant gauge manifold to the suction line service valve.

Step 4. Attach a thermocouple to the suction line near the suction line service valve. Be sure the sensor is in direct contact with the line and is well insulated from air temperature.

Step 5. Attach a thermocouple to measure the condenser (entering) air dry-bulb temperature. The sensor shall be placed so that it records the average condenser air entering temperature and is shaded from direct sun.

Step 6. Be sure that all cabinet panels that affect airflow are in place before making measurements. The thermocouple sensors shall remain attached to the system until the final charge is determined.

Step 7. Place wet-bulb thermocouple in water to ensure it is saturated when needed. **Do not get the dry-bulb thermocouples wet.**

Step 8. Insert the dry-bulb thermocouple in the supply plenum at the center of the airflow.

Step 9. At 12 minutes, insert a dry-bulb thermocouple and a wet-bulb thermocouple into the return plenum at the center of the airflow.

Step 10. At 15 minutes when the return plenum temperatures have stabilized, using the thermocouples already in place, measure and record the return (evaporator entering) air dry-bulb temperature ($T_{return,\ db}$) and the return (evaporator entering) air wet-bulb temperature ($T_{return,\ wb}$).

Step 11. Using the dry-bulb thermocouple already in place, measure and record the supply (evaporator leaving) air dry-bulb temperature ($T_{supply,\ db}$).

Step 12. Using the refrigerant gauge already attached, measure and record the evaporator saturation temperature ($T_{evaporator,\ sat}$) from the low side gauge.

Step 13. Using the dry-bulb thermocouple already in place, measure and record the suction line temperature ($T_{suction,\ db}$).

Step 14. Using the dry-bulb thermocouple already in place, measure and record the condenser (entering) air dry-bulb temperature ($T_{condenser,\ db}$).

The above measurements shall be used to adjust refrigerant charge and airflow as described in following sections.

2.5 Refrigerant Charge Calculations

The Superheat Charging Method is used only for non-TXV systems equipped with fixed metering devices. These include capillary tubes and piston-type metering devices. The following steps describe the calculations to determine if the system meets the required refrigerant charge using the measurements described in section 2.4. If a system fails, then remedial actions must be taken. If the refrigerant charge is changed and the airflow has been previously tested and shown to pass, then the airflow shall be re-tested. Be sure to complete Steps 1 and 2 of Section 2.4 before re-testing the airflow. Both the airflow and charge must be re-tested until they both sequentially pass.

Step 1. Calculate Actual Superheat as the suction line temperature minus the evaporator saturation temperature.
Actual Superheat = $T_{suction,\ db} - T_{evaporator,\ sat}$.

Step 2. Determine the Target Superheat using Table K-1 using the return air wet-bulb temperature ($T_{return, wb}$) and condenser air dry-bulb temperature ($T_{condenser, db}$).

Step 3. If a dash mark is read from Table K-1, the target superheat is less than 5°F, then the system **does not pass** the required refrigerant charge criteria, usually because outdoor conditions are too hot and dry. One of the following adjustments is needed until a target superheat value can be obtained from Table K-1 by either 1) turning on the space heating system and/or opening the windows to warm up indoor temperature; or 2) retest at another time when conditions are different. After adjustments, repeat the measurement procedure as often as necessary to establish the target superheat. Allow system to stabilize for 15 minutes before completing the measurement procedure again.

Step 4. Calculate the difference between actual superheat and target superheat (Actual Superheat - Target Superheat)

Step 5. If the difference is between minus 5 and plus 5°F, then the system **passes** the required refrigerant charge criteria.

Step 6. If the difference is greater than plus 5°F, then the system **does not pass** the required refrigerant charge criteria and the installer shall add refrigerant. After the refrigerant has been added, turn the system on and allow it to stabilize for 15 minutes before completing the measurement procedure again. Adjust refrigerant charge and repeat the measurement procedure as many times as necessary to pass the test.

Step 7. If the difference is between –5 and -100°F, then the system **does not pass** the required refrigerant charge criteria, the installer shall remove refrigerant. After the refrigerant has been removed, turn the system on and allow it to stabilize for 15 minutes before completing the measurement procedure again. Adjust refrigerant charge and repeat the measurement as many times as necessary to pass the test.

Table K-1: Target Superheat (Suction Line Temperature - Evaporator Saturation Temperature)

Condenser Air Dry-Bulb Temperature (°F) ($T_{condenser,\ db}$)	Return Air Wet-Bulb Temperature (°F) ($T_{return,\ wb}$)																												
	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
55	8.8	10.1	11.5	12.8	14.2	15.6	17.1	18.5	20.0	21.5	23.1	24.6	26.2	27.8	29.4	31.0	32.4	33.8	35.1	36.4	37.7	39.0	40.2	41.5	42.7	43.9	45.0
56	8.6	9.9	11.2	12.6	14.0	15.4	16.8	18.2	19.7	21.2	22.7	24.2	25.7	27.3	28.9	30.5	31.8	33.2	34.6	35.9	37.2	38.5	39.7	41.0	42.2	43.4	44.6
57	8.3	9.6	11.0	12.3	13.7	15.1	16.5	17.9	19.4	20.8	22.3	23.8	25.3	26.8	28.3	29.9	31.3	32.6	34.0	35.3	36.7	38.0	39.2	40.5	41.7	43.0	44.2
58	7.9	9.3	10.6	12.0	13.4	14.8	16.2	17.6	19.0	20.4	21.9	23.3	24.8	26.3	27.8	29.3	30.7	32.1	33.5	34.8	36.1	37.5	38.7	40.0	41.3	42.5	43.7
59	7.5	8.9	10.2	11.6	13.0	14.4	15.8	17.2	18.6	20.0	21.4	22.9	24.3	25.7	27.2	28.7	30.1	31.5	32.9	34.3	35.6	36.9	38.3	39.5	40.8	42.1	43.3
60	7.0	8.4	9.8	11.2	12.6	14.0	15.4	16.8	18.2	19.6	21.0	22.4	23.8	25.2	26.6	28.1	29.6	31.0	32.4	33.7	35.1	36.4	37.8	39.1	40.4	41.6	42.9
61	6.5	7.9	9.3	10.7	12.1	13.5	14.9	16.3	17.7	19.1	20.5	21.9	23.3	24.7	26.1	27.5	29.0	30.4	31.8	33.2	34.6	35.9	37.3	38.6	39.9	41.2	42.4
62	6.0	7.4	8.8	10.2	11.7	13.1	14.5	15.9	17.3	18.7	20.1	21.4	22.8	24.2	25.5	27.0	28.4	29.9	31.3	32.7	34.1	35.4	36.8	38.1	39.4	40.7	42.0
63	5.3	6.8	8.3	9.7	11.1	12.6	14.0	15.4	16.8	18.2	19.6	20.9	22.3	23.6	25.0	26.4	27.8	29.3	30.7	32.2	33.6	34.9	36.3	37.7	39.0	40.3	41.6
64	-	6.1	7.6	9.1	10.6	12.0	13.5	14.9	16.3	17.7	19.0	20.4	21.7	23.1	24.4	25.8	27.3	28.7	30.2	31.6	33.0	34.4	35.8	37.2	38.5	39.9	41.2
65	-	5.4	7.0	8.5	10.0	11.5	12.9	14.3	15.8	17.1	18.5	19.9	21.2	22.5	23.8	25.2	26.7	28.2	29.7	31.1	32.5	33.9	35.3	36.7	38.1	39.4	40.8
66	-		6.3	7.8	9.3	10.8	12.3	13.8	15.2	16.6	18.0	19.3	20.7	22.0	23.2	24.6	26.1	27.6	29.1	30.6	32.0	33.4	34.9	36.3	37.6	39.0	40.4
67	-	-	5.5	7.1	8.7	10.2	11.7	13.2	14.6	16.0	17.4	18.8	20.1	21.4	22.7	24.1	25.6	27.1	28.6	30.1	31.5	33.0	34.4	35.8	37.2	38.6	39.9
68	-	-	-	6.3	8.0	9.5	11.1	12.6	14.0	15.5	16.8	18.2	19.5	20.8	22.1	23.5	25.0	26.5	28.0	29.5	31.0	32.5	33.9	35.3	36.8	38.1	39.5
69	-	-	-	5.5	7.2	8.8	10.4	11.9	13.4	14.8	16.3	17.6	19.0	20.3	21.5	22.9	24.4	26.0	27.5	29.0	30.5	32.0	33.4	34.9	36.3	37.7	39.1
70	-	-	-	-	6.4	8.1	9.7	11.2	12.7	14.2	15.7	17.0	18.4	19.7	20.9	22.3	23.9	25.4	27.0	28.5	30.0	31.5	33.0	34.4	35.9	37.3	38.7
71	-	-	-	-	5.6	7.3	8.9	10.5	12.1	13.6	15.0	16.4	17.8	19.1	20.3	21.7	23.3	24.9	26.4	28.0	29.5	31.0	32.5	34.0	35.4	36.9	38.3
72	-	-	-	-	-	6.4	8.1	9.8	11.4	12.9	14.4	15.8	17.2	18.5	19.7	21.2	22.8	24.3	25.9	27.4	29.0	30.5	32.0	33.5	35.0	36.5	37.9
73	-	-	-	-	-	5.6	7.3	9.0	10.7	12.2	13.7	15.2	16.6	17.9	19.2	20.6	22.2	23.8	25.4	26.9	28.5	30.0	31.5	33.1	34.6	36.0	37.5
74	-	-	-	-	-	-	6.5	8.2	9.9	11.5	13.1	14.5	15.9	17.3	18.6	20.0	21.6	23.2	24.8	26.4	28.0	29.5	31.1	32.6	34.1	35.6	37.1
75	-	-	-	-	-	-	5.6	7.4	9.2	10.8	12.4	13.9	15.3	16.7	18.0	19.4	21.1	22.7	24.3	25.9	27.5	29.1	30.6	32.2	33.7	35.2	36.7
76	-	-	-	-	-	-	-	6.6	8.4	10.1	11.7	13.2	14.7	16.1	17.4	18.9	20.5	22.1	23.8	25.4	27.0	28.6	30.1	31.7	33.3	34.8	36.3
77	-	-	-	-	-	-	-	5.7	7.5	9.3	11.0	12.5	14.0	15.4	16.8	18.3	20.0	21.6	23.2	24.9	26.5	28.1	29.7	31.3	32.8	34.4	36.0
78	-	-	-	-	-	-	-	-	6.7	8.5	10.2	11.8	13.4	14.8	16.2	17.7	19.4	21.1	22.7	24.4	26.0	27.6	29.2	30.8	32.4	34.0	35.6
79	-	-	-	-	-	-	-	-	5.9	7.7	9.5	11.1	12.7	14.2	15.6	17.1	18.8	20.5	22.2	23.8	25.5	27.1	28.8	30.4	32.0	33.6	35.2
80	-	-	-	-	-	-	-	-	-	6.9	8.7	10.4	12.0	13.5	15.0	16.6	18.3	20.0	21.7	23.3	25.0	26.7	28.3	29.9	31.6	33.2	34.8
81	-	-	-	-	-	-	-	-	-	6.0	7.9	9.7	11.3	12.9	14.3	16.0	17.7	19.4	21.1	22.8	24.5	26.2	27.9	29.5	31.2	32.8	34.4
82	-	-	-	-	-	-	-	-	-	5.2	7.1	8.9	10.6	12.2	13.7	15.4	17.2	18.9	20.6	22.3	24.0	25.7	27.4	29.1	30.7	32.4	34.0
83	-	-	-	-	-	-	-	-	-	-	6.3	8.2	9.9	11.6	13.1	14.9	16.6	18.4	20.1	21.8	23.5	25.2	26.9	28.6	30.3	32.0	33.7
84	-	-	-	-	-	-	-	-	-	-	5.5	7.4	9.2	10.9	12.5	14.3	16.1	17.8	19.6	21.3	23.0	24.8	26.5	28.2	29.9	31.6	33.3
85	-	-	-	-	-	-	-	-	-	-	-	6.6	8.5	10.3	11.9	13.7	15.5	17.3	19.0	20.8	22.6	24.3	26.0	27.8	29.5	31.2	32.9
86	-	-	-	-	-	-	-	-	-	-	-	5.8	7.8	9.6	11.3	13.2	15.0	16.7	18.5	20.3	22.1	23.8	25.6	27.3	29.1	30.8	32.6
87	-	-	-	-	-	-	-	-	-	-	-	5.0	7.0	8.9	10.6	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.1	26.9	28.7	30.4	32.2
88	-	-	-	-	-	-	-	-	-	-	-	-	6.3	8.2	10.0	12.0	13.9	15.7	17.5	19.3	21.1	22.9	24.7	26.5	28.3	30.1	31.8
89	-	-	-	-	-	-	-	-	-	-	-	-	5.5	7.5	9.4	11.5	13.3	15.1	17.0	18.8	20.6	22.4	24.3	26.1	27.9	29.7	31.5
90	-	-	-	-	-	-	-	-	-	-	-	-	-	6.8	8.8	10.9	12.8	14.6	16.5	18.3	20.1	22.0	23.8	25.6	27.5	29.3	31.1

Table K-1: Target Superheat (Suction Line Temperature - Evaporator Saturation Temperature) (continued)

Condenser Air Dry-Bulb Temperature (°F) ($T_{condenser, db}$)	Return Air Wet-Bulb Temperature (°F) ($T_{return, wb}$)																													
	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
91	-	-	-	-	-	-	-	-	-	-	-	-	-	6.1	8.1	10.3	12.2	14.1	15.9	17.8	19.7	21.5	23.4	25.2	27.1	28.9	30.8
92	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4	7.5	9.8	11.7	13.5	15.4	17.3	19.2	21.1	22.9	24.8	26.7	28.5	30.4
93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.8	9.2	11.1	13.0	14.9	16.8	18.7	20.6	22.5	24.4	26.3	28.2	30.1
94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	8.7	10.6	12.5	14.4	16.3	18.2	20.2	22.1	24.0	25.9	27.8	29.7
95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.6	8.1	10.0	12.0	13.9	15.8	17.8	19.7	21.6	23.6	25.5	27.4	29.4
96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.5	9.5	11.4	13.4	15.3	17.3	19.2	21.2	23.2	25.1	27.1	29.0
97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.0	8.9	10.9	12.9	14.9	16.8	18.8	20.8	22.7	24.7	26.7	28.7
98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.4	8.4	10.4	12.4	14.4	16.4	18.3	20.3	22.3	24.3	26.3	28.3
99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.8	7.9	9.9	11.9	13.9	15.9	17.9	19.9	21.9	24.0	26.0	28.0
100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.3	7.3	9.3	11.4	13.4	15.4	17.5	19.5	21.5	23.6	25.6	27.7
101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.8	8.8	10.9	12.9	15.0	17.0	19.1	21.1	23.2	25.3	27.3
102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	8.3	10.4	12.4	14.5	16.6	18.6	20.7	22.8	24.9	27.0
103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7	7.8	9.9	11.9	14.0	16.1	18.2	20.3	22.4	24.5	26.7
104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.2	7.2	9.3	11.5	13.6	15.7	17.8	19.9	22.1	24.2	26.3
105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	8.8	11.0	13.1	15.2	17.4	19.5	21.7	23.8	26.0
106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	8.3	10.5	12.6	14.8	17.0	19.1	21.3	23.5	25.7
107	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7	7.9	10.0	12.2	14.4	16.6	18.7	21.0	23.2	25.4
108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.2	7.4	9.5	11.7	13.9	16.1	18.4	20.6	22.8	25.1
109	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	9.1	11.3	13.5	15.7	18.0	20.2	22.5	24.7
110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.4	8.6	10.8	13.1	15.3	17.6	19.9	22.1	24.4
111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.9	8.1	10.4	12.6	14.9	17.2	19.5	21.8	24.1
112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4	7.6	9.9	12.2	14.5	16.8	19.1	21.5	23.8
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.2	9.5	11.8	14.1	16.4	18.8	21.1	23.5
114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	9.0	11.4	13.7	16.1	18.4	20.8	23.2
115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	8.6	10.9	13.3	15.7	18.1	20.5	22.9

2.6 Adequate Airflow Calculations

The temperature split method is designed to provide an efficient check to see if airflow is above the required minimum. The following steps describe the calculations using the measurement procedure described in section 2.4. If a system fails, then remedial actions must be taken. If the airflow is changed and the refrigerant charge has previously been tested and shown to pass, then the refrigerant charge shall be re-tested. Be sure to complete Steps 1 and 2 of Section 2.4 before re-testing the refrigerant charge. Both the airflow and charge must be re-tested until they both sequentially pass.

Step 1. Calculate the Actual Temperature Split as the return air dry-bulb temperature minus the supply air dry-bulb temperature. Actual Temperature Split = $T_{return,\ db} - T_{supply,\ db}$

Step 2. Determine the Target Temperature Split from Table K-2 using the return air wet-bulb temperature ($T_{return,\ wb}$) and return air dry-bulb temperature ($T_{return,\ db}$).

Step 3. If a dash mark is read from Table K-2, then there probably was an error in the measurements because the conditions in this part of the table would be extremely unusual. If this happens, re-measure the temperatures. If re-measurement results in a dash mark, complete one of the alternate airflow measurements in Section 3.4 below.

Step 4. Calculate the difference between target and actual temperature split (Actual Temperature Split-Target Temperature Split). If the difference is within plus 3°F and minus 3°F, then the system **passes** the adequate airflow criteria.

Step 5. If the difference is greater than plus 3°F, then the system **does not pass** the adequate airflow criteria and the airflow shall be increased by the installer. Increasing airflow can be accomplished by eliminating restrictions in the duct system, increasing blower speed, cleaning filters, or opening registers. After corrective measures are taken, repeat measurement procedure as often as necessary to establish adequate airflow range. Allow system to stabilize for 15 minutes before repeating measurement procedure.

Step 6. If the difference is between minus 3°F and minus 100°F, then the measurement procedure shall be repeated making sure that temperatures are measured at the center of the airflow.

Step 7. If the re-measured difference is between plus 3°F and minus 3°F the system **passes** the adequate airflow criteria. If the re-measured difference is between minus 3°F and minus 100°F, the system passes, but it is likely that the capacity is low on this system (it is possible, but unlikely, that airflow is higher than average).

Table K-2: Target Temperature Split (Return Dry-Bulb – Supply Dry-Bulb)

Return Air Dry–Bulb (°F) ($T_{return, db}$)	Return Air Wet-Bulb (°F) ($T_{return, wb}$)																												
	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
70	20.9	20.7	20.6	20.4	20.1	19.9	19.5	19.1	18.7	18.2	17.7	17.2	16.5	15.9	15.2	14.4	13.7	12.8	11.9	11.0	10.0	9.0	7.9	6.8	5.7	4.5	3.2
71	21.4	21.3	21.1	20.9	20.7	20.4	20.1	19.7	19.3	18.8	18.3	17.7	17.1	16.4	15.7	15.0	14.2	13.4	12.5	11.5	10.6	9.5	8.5	7.4	6.2	5.0	3.8
72	21.9	21.8	21.7	21.5	21.2	20.9	20.6	20.2	19.8	19.3	18.8	18.2	17.6	17.0	16.3	15.5	14.7	13.9	13.0	12.1	11.1	10.1	9.0	7.9	6.8	5.6	4.3
73	22.5	22.4	22.2	22.0	21.8	21.5	21.2	20.8	20.3	19.9	19.4	18.8	18.2	17.5	16.8	16.1	15.3	14.4	13.6	12.6	11.7	10.6	9.6	8.5	7.3	6.1	4.8
74	23.0	22.9	22.8	22.6	22.3	22.0	21.7	21.3	20.9	20.4	19.9	19.3	18.7	18.1	17.4	16.6	15.8	15.0	14.1	13.2	12.2	11.2	10.1	9.0	7.8	6.6	5.4
75	23.6	23.5	23.3	23.1	22.9	22.6	22.2	21.9	21.4	21.0	20.4	19.9	19.3	18.6	17.9	17.2	16.4	15.5	14.7	13.7	12.7	11.7	10.7	9.5	8.4	7.2	5.9
76	24.1	24.0	23.9	23.7	23.4	23.1	22.8	22.4	22.0	21.5	21.0	20.4	19.8	19.2	18.5	17.7	16.9	16.1	15.2	14.3	13.3	12.3	11.2	10.1	8.9	7.7	6.5
77	-	24.6	24.4	24.2	24.0	23.7	23.3	22.9	22.5	22.0	21.5	21.0	20.4	19.7	19.0	18.3	17.5	16.6	15.7	14.8	13.8	12.8	11.7	10.6	9.5	8.3	7.0
78	-	-	-	24.7	24.5	24.2	23.9	23.5	23.1	22.6	22.1	21.5	20.9	20.2	19.5	18.8	18.0	17.2	16.3	15.4	14.4	13.4	12.3	11.2	10.0	8.8	7.6
79	-	-	-	-	-	24.8	24.4	24.0	23.6	23.1	22.6	22.1	21.4	20.8	20.1	19.3	18.5	17.7	16.8	15.9	14.9	13.9	12.8	11.7	10.6	9.4	8.1
80	-	-	-	-	-	-	25.0	24.6	24.2	23.7	23.2	22.6	22.0	21.3	20.6	19.9	19.1	18.3	17.4	16.4	15.5	14.4	13.4	12.3	11.1	9.9	8.7
81	-	-	-	-	-	-	-	25.1	24.7	24.2	23.7	23.1	22.5	21.9	21.2	20.4	19.6	18.8	17.9	17.0	16.0	15.0	13.9	12.8	11.7	10.4	9.2
82	-	-	-	-	-	-	-	-	25.2	24.8	24.2	23.7	23.1	22.4	21.7	21.0	20.2	19.3	18.5	17.5	16.6	15.5	14.5	13.4	12.2	11.0	9.7
83	-	-	-	-	-	-	-	-	-	25.3	24.8	24.2	23.6	23.0	22.3	21.5	20.7	19.9	19.0	18.1	17.1	16.1	15.0	13.9	12.7	11.5	10.3
84	-	-	-	-	-	-	-	-	-	25.9	25.3	24.8	24.2	23.5	22.8	22.1	21.3	20.4	19.5	18.6	17.6	16.6	15.6	14.4	13.3	12.1	10.8

3. Alternate Charge and Airflow Measurement Procedure

This section specifies the Alternate charge and airflow measurement procedure. Under this procedure, the required refrigerant charge is calculated using the *Weigh-In Charging Method* and adequate airflow across the evaporator coil is calculated using the *Measured Airflow Method.*

HVAC installers who must complete system installation verification when the outdoor temperature is below 55°F shall use this Alternate procedure in conjunction with installing and charging the system in accordance with the manufacturer's specifications. HERS Raters shall not use this procedure to verify compliance.

Split system air conditioners come from the factory already charged with the standard charge indicated on the name plate. The manufacturer supplies the charge proper for the application based on their standard liquid line length. It is the responsibility of the HVAC installer to ensure that the charge is correct for each air conditioner and to adjust the charge based on liquid line length different from the manufacturer's standard.

3.1 Minimum Qualifications for this Procedure

HVAC installation technicians need to be qualified to perform the following:

- Transfer and recovery of refrigerant (including a valid Environmental Protection Agency (EPA) certification for transition and recovery of refrigerant).
- Accurately weigh the amount of refrigerant added or removed using an electronic scale.
- Calculate the refrigerant charge adjustment needed to compensate for non-standard lineset lengths/diameters based on the actual lineset length/diameter and the manufacturer's specifications for adjusting refrigerant charge for non-standard lineset lengths/diameters.

3.2 Instrumentation Specifications

Instrumentation for the procedures described in this section shall conform to the following specifications.

3.2.1 Digital Charging Scale

The digital scale used to weigh in refrigerant must have a range of .5 oz to at least 1200 oz (75 lb.). The scale's accuracy must be ± 0.25 oz.

3.3 Weigh-In Method

The following procedure shall be used by the HVAC installer to charge the system with the correct refrigerant charge.

Step 1. Obtain manufacturer's standard liquid line length and charge adjustment for alternate liquid line lengths.

Step 2. Measure and record the actual liquid line length (L_{actual}).

Step 3. Record the manufacturer's standard liquid line length ($L_{standard}$).

Step 4. Calculate the difference between actual and standard liquid line lengths ($L_{actual} - L_{standard}$).

Step 5. Record the manufacturer's adjustment for liquid line length difference per foot (A_{length}).

Step 6. Calculate the amount of refrigerant to add or remove and document the calculations on the CF-6R.

Step 7. Weigh in or remove the correct amount of refrigerant

3.4 Airflow Measurement

The airflow across the indoor evaporator coil shall be measured using one of the 2 methods described Appendix F - Standard Procedure for Determining the Seasonal Energy Efficiencies of Residential Air Distribution Systems:

Section 4.3.7.2.1 Diagnostic Fan Flow Using Flow Hood

Section 4.3.7.2.2 Diagnostic Fan Flow Using Plenum Pressure Matching

3.5 Adequate Airflow Calculation

The measured airflow method is used to provide a check to see if airflow is above the required minimum of 385 CFM per nominal ton of capacity (assumes coil is dry). The following steps describe the calculations using the measurement procedure described in Section 3.4. If a system fails, then remedial actions must be taken. The airflow must be re-tested until it passes.

Step 1. Record the measured airflow ($F_{measured}$) obtained from the measurement procedures described in Section 3.4.

Step 2. Obtain and record the rated cooling capacity ($C_{cooling}$) in Btu.

Step 3. Calculate the required airflow as the product of the rated cooling capacity in Btu times 0.032.

Step 4. Compare the airflow measured according to section 3.4 with the required airflow.

Step 5. If the measured airflow is greater than the required airflow, then the system **passes** the adequate airflow criteria.

Step 6. If the measured airflow is less than the required airflow, the system does not pass the adequate airflow criteria and the airflow shall be increased by the installer. Increasing airflow can be accomplished by eliminating restrictions in the duct system, increasing blower speed, cleaning filters, or opening registers. After corrective measures are taken, repeat measurement procedure.

PROPOSED REVISIONS TO THE NONRESIDENTIAL ACM MANUAL

1. Chiller Characteristics, Correction to more accurately model chiller performance

2.4.2.31 Chiller Characteristics

Description: The ACM chiller model must, at a minimum, incorporate the following characteristics:

- *Minimum Ratio:* The minimum capacity for a chiller below which it cycles.
- *Electrical Input Ratio:* Efficiency of the chiller at rated conditions. It is the ratio of the electrical power input to the chiller to the nominal capacity of the chiller.
- *Condenser Type:* It specifies whether the condenser is air-cooled or water-cooled.
- *GPM perTon:* The ratio of cooling tower water flow in GPM to chiller capacity in tons.

DOE Keyword:
SIZE
MIN-RATIO
EIR
*-COND-TYPE
COMP-TO-TWR-WTR

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model chiller characteristics as follows:

- SIZE: The chiller size shall be calculated as follows

$$SIZE = \frac{Q_{des\_i} \times 0.012}{CAPFT\left(t_{chws\_des}, t_{cws\_des}\right)}$$

where

Q_{des_i} = Chiller design capacity (in tons) at reference conditions
t_{chws_des} = Chilled water supply temperature at design conditions
t_{cws_des} = Condenser water supply temperature at design conditions
CAPFT() = Capacity performance curve (see 2.4.2.33)

- ***Minimum Ratio:*** For chillers with customized curves, ACMs shall calculate the *minimum ratio* using the part-load data by

$$MIN-RATIO = \frac{Q_{des\_i}}{\text{Minimum}\left(\left[Q_{pload\_i1}, Q_{pload\_i2}, \ldots, Q_{pload\_ij}\right]\right)}$$

where

Q_{pload_ij} = Chiller part-load performance data, Capacity in tons

Q_{des_i} = Chiller design capacity (in tons)

The default *minimum ratio* values are shown in the Table below.

Chiller Type	**Default Unloading Ratio**
Reciprocating	25%
Screw	15%
Centrifugal	10%
Scroll	25%
Single Effect Absorption	10%
Double Effect Absorption	10%

- ***Electrical Input Ratio***: ACMs shall calculate the Electrical Input Ratio (EIR) for chillers with customized performance curves from the user input data.

$$E-I-R = \frac{P_{des\_i} \times 3.413}{Q_{des\_i} \times EIRFT\left(t_{chws\_des}, t_{cws\_des}\right) \times EIRFPLR(1.0) \times 12.0}$$

~~$E-I-R = \frac{P_{des\_i} \times 3.413}{Q_{des\_i} \times 12.0}$~~

where

P_{des_i} = Chiller design input power at design conditions t_{chws_des} and t_{cws_des} (in kW)

Q_{des_i} = Chiller design capacity at design conditions t_{chws_des} and t_{cws_des} (in tons)

EIRFT()= Efficiency performance curve (see 2.4.2.33)
EIRFPLR()= Efficiency performance curve (see 2.4.2.33)

For other chillers, ACMs shall calculate the EIR using

~~$E - I - R = \frac{1}{COP}$~~

$$E - I - R = \frac{1}{COP \times EIRFT(44,85) \times EIRFPLR(1.0)}$$

where

COP = Coefficient of Performance
EIRFT()= Efficiency performance curve (see 2.4.2.33)
EIRFPLR()= Efficiency performance curve (see 2.4.2.33)

- ***Condenser Type****:* ACMs shall require the user to input whether the chiller is air-cooled or water-cooled.

- ***GPM per Ton****:* For water-cooled chillers with customized performance curves, ACMs shall determine the condenser water flow as a ratio of condenser water flow rate (GPM) to rated chiller capacity (tons) using the following equation.

$$COMP - TO - TWR - WTR = \frac{\sum_{i=1}^{n} GPM_{cond\_i}}{\sum_{i=1}^{m} Q_{des\_i}}$$

where

GPM_{cond_i} = Condenser flow rate (in GPM)
Q_{des_i} = Chiller design capacity (in tons)
n = Number of condensers
m = Number of chillers

For default water-cooled chillers, ACMs shall determine the condenser water flow as follows.

$$COMP - TO - TWR - WTR = \left[1 + \frac{1}{\frac{\sum_{i=1}^{n} (COP_i \times SIZE_i)}{\sum_{i=1}^{n} SIZE_i}} \right] \times 2.4$$

where

COP_i = Coefficient of performance for chiller i

$SIZE_i = \frac{Q_{des\_i} \times 12{,}000}{1{,}000{,}000}$

n = Number of chillers

Modeling Rules for Reference Design (New & Altered Existing):

ACMs shall model chiller characteristics for the reference design as follows:

- SIZE: The chiller size shall be calculated as follows

$$SIZE = \frac{Q_i \times 0.012}{CAPFT(44{,}85)}$$

where

Q_i = Chiller capacity (in tons) at ARI reference conditions
CAPFT()= Capacity performance curve (see 2.4.2.33)

- ***Minimum Ratio:*** ACMs shall calculate the *minimum ratio* default values are shown in the Table below.

Chiller Type	**Default Unloading Ratio**
Reciprocating	25%
Screw	15%
Centrifugal	10%
Scroll	25%
Single Effect Absorption	10%
Double Effect Absorption	10%

- ***Electrical Input Ratio***: ACMs shall calculate the Electrical Input Ratio (EIR) for the reference design using

~~$E - I - R = \frac{1}{COP}$~~

$$E - I - R = \frac{1}{COP \times EIRFT(44{,}85) \times EIRFPLR(1.0)}$$

where

COP = Coefficient of Performance
EIRFT()= Efficiency performance curve (see 2.4.2.33)
EIRFPLR()= Efficiency performance curve (see 2.4.2.33)

- ***Condenser Type**:* ACMs shall model water-cooled condenser for the reference design.

  *-COND-TYPE = TOWER

- ***GPM per Ton**:* For water-cooled chillers with, ACMs shall determine the condenser water flow as follows.

$$COMP-TO-TWR-WTR=\left[1+\frac{1}{\frac{\sum_{i=1}^{n}(COP_i\times SIZE_i)}{\sum_{i=1}^{n}SIZE_i}}\right]\times 2.4$$

where

COP_i = Coefficient of performance for chiller i

$SIZE_i=\frac{Q_{des\_i}\times 12{,}000}{1{,}000{,}000}$

n = Number of chillers

Modeling Rules for Reference Design (Existing Unchanged): ACMs shall model the existing chiller(s) using the actual data. If the actual data is not available, ACMs shall model the existing design the same as the reference design.